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ABSTRACT

The effects on reading speed and comprehension of window proportions and page turning in electronic text were investigated in this study. Subjects--61 undergraduate students at the University of Wisconsin--Whitewater--were administered a standardized reading text displayed as photocopied dot matrix print in simulation of electronic text. There were two levels of window--a single window containing a whole passage or multiple windows of six lines each--and reading took place under restricted or unrestricted page turning conditions. Each subject was asked to read two narrative prose passages and answer nine multiple choice questions on the two passages in 10 minutes. Analysis of the test scores indicated that: (1) there were significant differences in reading speeds for restricted and unrestricted page turning in either window condition, as the freedom to turn back to previous windows had a detrimental effect on speed; (2) the effects of different proportions of window on reading speed and comprehension were not significant; and (3) the multiple windows group tended to comprehend more than the single window group in the restricted page turning condition, and less in the unrestricted page turning condition. A list of 22 references is provided. (MES)

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Electronic Text Display:

An Experiment on Page Turning and Window Effect

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Abstract

Readers of electronic text view the text through a window formed by an area of the display screen. To evaluate the restriction that electronic text makes on readers by limiting random access to those windows, subjects in this experiment read passages from a reading test. There were two levels of window: a single window containing a whole passage and multiple windows of six lines each. Reading took place under two conditions: restricted and unrestricted page turning. There were two dependent measures: comprehension and speed of reading. Directional restriction on linear reading had no significant effect on comprehension but free turning back to previous windows was significantly detrimental in terms of reading speed for either proportion of window. The two levels of window were not significantly different. This raises the question of reader access to text versus reading efficiency and presents a new objective to designers of electronic displays for reading.

Electronic Text Display: An Experiment on Page Turning and Window Effect

The technology of text displayed on printed paper developed through trial and error over several centuries but the display of continuous prose on electronic screens is becoming widespread without the benefit of testing beyond the visibility of individual characters. This appears as a research issue in several forms (Cushman, 1986, Kak, 1981; Kolers, Duchnick and Ferguson, 1981; Muter, Latremouille, Treumiet and Beam, 1982; Snyder and Maddox, 1978). Empirical recommendations for legible printing on paper are given by Tinker's safety zones for print (1963) and are considered in the design of printed text as meaningful, running prose. The major variables for the usual black on white, upper and lower case printing are character size, line length and interline spacing; these vary with the font and style of type. Design decisions for reading electronic text have been based on the distinction of discrete alphanumerics rather than actual reading (Gould, 1968, Shurtleff, 1980; Smith, 1979). This is due to the initial applications of display devices such as cathode ray tubes for military control and command tasks. In contrast, a predominant mode of information delivery is text and it is increasingly conveyed by display screens.

The substantial difference between the old and the new reading media requires empirical investigation. As hard copy, pages are their own storage medium and their own display medium. As soft copy, the screen must draw upon a secondary storage medium, such as a disk or a chip. This difference changes the technology of reading beyond traditional legibility variables. Two new variables to consider in this respect are the size of the window into the text and the freedom of access to these windows.

Window

Readers of electronic text view the text through a window formed by an area of the display screen. A printed page, such as this one, is also a window into the text. However, a printed page is a much larger window than that of electronic text displays affordable at present. Several screen windows would be needed to convey this page.

Hartley reports that the research literature has not been useful in determining the pagesize of printed instructional text (1978, p. 9-12) but identifies its importance as the basic design unit. Window is the electronic version of pagesize and has the equivalent interaction with other text elements, including the major variables. Unlike the pagesize of printed paper, the window of an electronic screen is limited--even in bit-mapped displays.

Though it is arbitrarily assigned like a page in a book, the window into the text can itself be a unit of meaning. The meaning of a window is what the readers attribute to it from the text displayed there. Raban's psycholinguistic study (1982), for example, indicated that the effect of printed text display on line length and line-breaks influences children's understanding of sentences. Similarly, reading an electronic text display may not induce a different psychological reading process from reading printed paper but may induce a different problem solving process. Waern and Rollenhagen provide commentary on this in their review paper (1983). When only a small window is allowed, readers may cope by adopting alternative cognitive strategies: the window effect (Yeaman, 1984).

Page turning

Free access to the text is a function of the size of the text window. As the number of screens bearing certain size windows increases, turning the page and unifying the mental image of each window's contents assumes a greater load on the reader's mental processing. An increase in the number of windows acts to lower comprehension. It is not known at what point there is an impairment in reading performance. It is safe to say that such a point probably exists.

Electronic text presents a new restriction to readers by limiting random access to windows. Paging is allowed in text editors, for instance, by one programmed function key for forward and another for back. This window mode is sequential in comparison to a book: the screen must fill before another window of text can be displayed.

Purpose

The purpose of this study was to seek empirical evidence of these two new variables as window effect and page turning. The variables were operationalized as two proportions of window and two page turning conditions for text access. Reading performance was evaluated by reading speed and comprehension, two measures theoretically based on the psychophysiological correlates of reading (Just and Carpenter, 1980). Reading speed and comprehension respectively represent partly distinct abilities that vary separately in individuals: visual word processing and nonvisual, linguistic processing (Palmer, MacLeod, Hunt and Davidson, 1985).

METHOD

Subjects

The target population was adult readers: a population containing approximately equal numbers of men and women who vary in reading ability, visual acuity and age. Subjects were 61 undergraduates drawn from spring term classes and offered extra credit for participation.

Instrumentation

The use of the 13-14 grade Sequential Test of Educational Progress (STEP) Series II Form A, a standardized, normed reading test, allowed a more realistic measure of reading performance than scanning rate or letter recognition threshold. A standardized, normed reading test demonstrates consistent reliability and validity over reading tests piloted with small numbers of readers (Carmichael and Dearborn, 1947, p. 239). In the experiment, there were 2 sets of 2 equivalent narrative prose passages and, in each administration, the students were asked to answer the 9 multiple choice questions on their 2 passages within 10 minutes.

Materials

The reading tests were displayed as photocopied dot matrix print in simulation of electronic text. The font produced by the Okidata 92 printer resembled 10 point type and the test passages were set up in approximation of Tinker's recommendations

(1963). The lines were single spaced and 52 characters in line length. The left margin was even and the lines were unjustified with a ragged right margin. In the single window display each text passage was visible as one complete window. In the multiple windows display the text for each passage was displayed through windows of six lines each--causing these passages to be presented through seven windows. Turning back to reread earlier text was prohibited in the restricted page turning administration. The students were expressly told in the unrestricted page turning administration that they could look back. The comprehension questions were displayed identically in each treatment.

Procedure

Students read the printed, formatted text in class group administrations. They read through the text by turning the page forward or, in the unrestricted page turning condition, by turning it forward and back. Students recorded their time of completion by writing it down in hours, minutes and seconds from a classroom wall clock. Responses to the STEP multiple choice questions were marked on printed answer sheets.

The procedures were identical for all treatments except that the text was displayed through different proportion windows and with or without restrictions on page turning for looking back. Students were randomly assigned to the window size groups. Single window passages were read by 28 students and another 30 students read multiple window passages. Twenty four students were randomly selected for the free text access condition--unrestricted page turning. These students were assigned the window treatment to which they had previously been exposed. They were joined by 3 new students so that 11 students read single window passages and 16 students read multiple window passages. A written script was followed to guide events closely to normal STEP administration.

RESULTS

Reading speed

A two-way analysis of variance was performed on the reading speeds for the 85 cases. Reading time was taken as the indication of speed. The mean times, in seconds, for the single window and the multiple windows groups respectively were 478.43 and 509.73, in the restricted page turning condition, and 552.36 and 560.94 in the unrestricted page turning condition. There were no significant differences for reading speed between the window treatment groups. There was a significant main effect for reading speed for both window treatment groups under restricted or unrestricted page turning, $F(1, 81) = 10.57$, $p < 0.01$, see Figure 1.

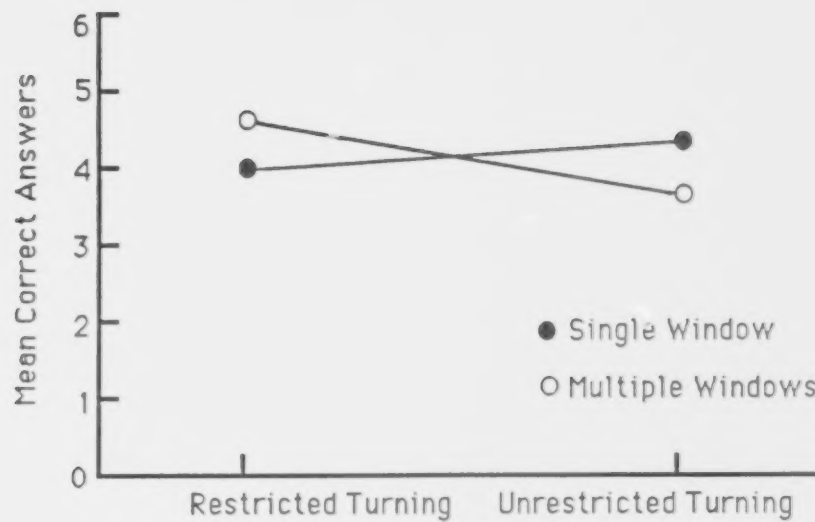


Figure 1. The reading speed of the window groups changed with the page turning condition.



Figure 2. The comprehension of the window groups changed with the page turning condition.

Comprehension

A two-way analysis of variance was performed on the scores. The mean reading scores for the single window and the multiple windows groups respectively were 4.00 and 4.53, in the restricted page turning condition, and 4.36 and 3.75 in the unrestricted page turning condition. There were no significant differences for the number of correct answers between any window treatment group, whether under restricted or unrestricted page turning.

Further Analysis

The relationships of the mean scores for correct answers is anomalous, see Figure 2. The single window score went up and the multiple windows score went down in the unrestricted page turning condition. This relationship was investigated further and the window groups' responses were compared with two-way analysis of variance for accuracy in answering the questions following each passage in each condition.

On the first comprehension questions in the restricted page turning condition, the one window per passage group scored lower ($M = 1.21$) than the multiple windows group ($M = 1.90$). For the first set of questions under unrestricted page turning the positions were reversed and the one window per passage group ($M = 2.55$) did better than the multiple windows group ($M = 2.44$). Two-way analysis of variance showed no significant difference between the levels of window but did show a significant difference between the page turning conditions: $F(1,81) = 10.25$, $p < 0.01$, see Figure 3.

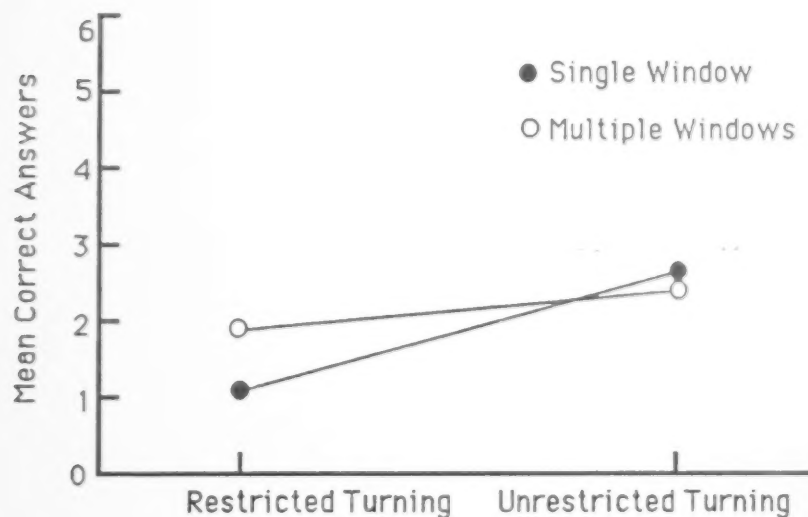


Figure 3. Relative to the first questions, the comprehension of the window groups changed with the page turning condition.

On the last comprehension questions in the restricted page turning condition, the one window per passage group scored higher ($M = 2.79$) than the multiple windows group ($M = 2.63$). For the second set of questions under unrestricted page turning the positions remained the same and the one window per passage group ($M = 1.82$) did better than the multiple windows group ($M = 1.31$). Two-way analysis of variance showed no significant difference between the levels of window but did show a significant difference between the page turning conditions: $F(1,81) = 17.08$, $p < 0.001$, see Figure 4.



Figure 4. Relative to the last questions, the comprehension of the window groups changed with the page turning condition.

Analysis of Reading Speed Decrease for Linear Relationships

Examination of the raw data indicated the likelihood of a linear relationship between the decrease of reading speed under unrestricted page turning and the students' fastest reading speeds. Correlation confirmed this interpretation for the single window group: $r = -0.62$, $p < 0.5$, slope = -0.90 and intercept = 543.01 . A linear relationship was also established for the multiple window group: $r = -0.91$, $p < 0.001$, slope = -1.17 and intercept = 590.77 . These results indicate that the slower the reading speed, the smaller the loss of reading speed in the unrestricted page turning condition and, conversely, the faster the reading speed, the larger the loss of reading speed in the unrestricted page turning condition.

DISCUSSION

The data empirically support the importance of page turning in text access. This was demonstrated by the comparison of reading speeds for restricted and unrestricted page turning. Readers apparently prefer to take the time required in unrestricted page turning

for looking backwards and forwards in the text--although no significant improvement in comprehension was found.

The effect of different proportions of window on reading speed and comprehension were not significant. This does not mean there are no differences, only that none were detected. Under restricted page turning, the single window group tended to be less efficient than the multiple windows group but the positions reversed for unrestricted page turning, see Figures 1 and Figure 2. A conjectural explanation for the reversal is that the degree of text access affected cognitive load to induce a varying trade off between reading speed and comprehension, between visual and linguistic processing.

Since text access has been shown to be a significant variable then it may be conjectured that window could also have an effect. Length of passage is another variable to consider: a passage 4 times as long would require 4 windows at one level and 28 at the other level. It is reasonable to expect that many small windows will detract from reading performance when compared with few large windows.

The multiple windows group tended to comprehend more than the single windows group in the restricted page turning condition and tended to comprehend less in the unrestricted page turning condition, see Figure 2. As illustrated by the post hoc analysis, this conclusion is limited by the single window group appearing adversely affected by warm up on the first passage: they did better on the second passage, having had a reading trial. It is possible the single window group did not read closely enough to do well on the first questions but this experience prepared them for the second passage. It is also possible that the multiple windows, being smaller, caused closer reading in the other group.

The single window group improved on the first questions under the condition of unrestricted page turning, see Figure 3, and did best on the last questions each time, see Figure 4. These differences between the groups were not significant. However, neither window group did significantly as well on the last questions under unrestricted page turning as they did under restricted page turning. It may be that they ran out of time. The human factoring of electronic reading must address these performance inequities.

The analysis of reading speed decreases indicate linear relationships between reading speed and the page turning condition. Access to electronic text may need to be different for different types of readers. Flexibility in reading display design is suggested to accommodate both slow readers and fast readers.

Reading behavior is a product of the reader's interest and ability, as moderated by perceptual and typographic factors. It may vary from one passage to another in addition to being dependent on the characteristics of each individual. For instance, in reviewing individual differences in response to computerized instruction Eberts and Brock (1984) refer to Larkin's observations (1981). Larkin reports that students doing physics practice problems differed in their reading behavior according to ability: *Poor students read through the text sequentially whereas good students used it as a reference source and jumped around in it, accessing it at random.* Eberts and Brock use this data to refer to

the branching aspects of computerized programmed instruction and suggest the capability of exploring text onscreen in a nonlinear fashion be part of the student-computer interface.

Comments from students reading text from microcomputer screens under similar experimental conditions as the study reported here reflect on the acceptability of the screen reading experience (Yeaman, 1984). There were many suggestions that the text would have been easier to comprehend had it been broken up into meaningful units on the screen rather than arbitrary windows. Many students preferred that sentences, at least, not be split from one screen to the next, although this is commonplace in books and periodicals with which they had much prior experience. In the ensuing discussions, students qualified this by comparison with the printed page where it is possible to turn back to the previous page as a check on meaning. It was quite clear from the students that reader control to go back in the text was very desirable: they wanted to check their understanding to give good answers. In addition, books as a familiar reading medium always allow this level of random access.

This converges with the two main reasons why people read that are identified by Smith (1982). Efferent reading is reading for instruction and can be readily evaluated through testing comprehension: the reader's absorption of information and inferences made as a consequence. Aesthetic reading is for enjoyment; reading for its own sake. Real life reading outside the laboratory--whether to acquire facts or experience pleasure or a mixture--is self-paced and page turning, forward and back, is under the reader's control. The question is how to best maintain that tradition for all readers with the shift to electronic delivery.

CONCLUSIONS

The development of electronic reading media not only incorporates the traditional aspects of typographic legibility and the novel aspects of light emitting displays (Wilkins, 1986) but also some new issues in text access (Line, 1980, 1981). The study reported here indicates significant changes in reading speed relative to the text access afforded by page turning conditions. The interaction of page turning and window effect suggests structuring the text image to avoid paging back and forth, sequentially through a succession of windows. For example, an electronic book could be developed as a visually organized database with an open text window onscreen and iconic representations of immediate access points.

REFERENCES

- Carmichael, L. and Dearborn, W. F. (1947). Reading and visual fatigue. Boston: Houghton Mifflin.
- Cushman, W. H. (1986). Reading from microfiche, a VDT, and the printed page: Subjective fatigue and performance. Human Factors, 28, 63-73.
- Eberts, R. and Brock, J. F. Computer applications to instruction. In F. A. Muckler (Ed.), Human factors review: 1984 (pp. 239-284). Santa Monica, CA: Human Factors Society.
- Gould, J. D. (1968). Visual factors in the design of computer-controlled CRT displays. Human Factors, 10, 359-376.
- Hartley, J. (1978). Designing instructional text. New York: Nichols.
- Just, M. A. and Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. Psychological Review, 87, 329-354.
- Kak, A. V. (1981). Relations between readability of printed and CRT-displayed text. In Proceedings of the Human Factors Society 25th Annual Meeting (pp. 137-140). Santa Monica, CA: Human Factors Society.
- Kolers, P. A., Ducknicky, R. L. and Ferguson, D. C. (1981). Eye movements measurement of readability of CRT displays. Human Factors, 23, 517-527.
- Larkin, J. H. (1981). Enriching formal knowledge: A model for learning to solve problems in physics. In J. R. Anderson (Ed.), Cognitive skills and their acquisition. Hillsdale, NJ: Erlbaum.
- Line, M. B. (1980). Some questions concerning the unprinted word. In P. J. Hills (Ed.), The future of the printed word: The impact and implications of the new communications technology (pp. 27-35). Westport, CT: Greenwood Press.
- Line, M. B. (1981). Redesigning information packages for electronic transmission. In K. P. Jones and H. Taylor (Eds.), The design of information systems for human beings: Informatics 6 (pp. 29-39). London: Aslib.
- Muter, P., Latremouille, S. A., Treurniet, W. C. and Beam, P. (1982). Extended reading of continuous text on television screens. Human Factors, 24, 501-508.
- Palmer, J., MacLeod, C. M., Hunt, E. and Davidson, J. E. (1985). Information processing correlates of reading. Journal of Memory and Language, 24, 59-88.
- Raban, B. (1982). Text display effects on the fluency of young readers. Journal of Research in Reading, 5, 7-28.

- Shurtleff, D. A. (1980). How to make displays legible. La Mirada, CA: Human Interface Design.
- Smith, F. (1982). Understanding reading: A psycholinguistic analysis of reading and learning to read. New York: Holt, Rinehart and Winston.
- Smith, S. L. (1979). Letter size and legibility. Human Factors, 21, 661-670.
- Snyder, H. L. and Maddox, M. E. (1978). Information transfer from computer-generated dot-matrix displays. (HFL-78-3/ARO-78-1) Research Triangle Park, NC: U.S. Army Research Office (NTIS No. AD-A063 505).
- Tinker, M. A. (1963). Legibility of print. Ames, IO: Iowa State University Press.
- Waern, Y. and Rollenhagen, C. (1983). Reading text from visual display units (VDUs). International Journal of Man-Machine Studies, 18, 441-465.
- Wilkins, A. (1986). Intermittent illumination from visual display units and fluorescent lighting affects movements of the eyes across text. Human Factors, 28, 75-81.
- Yeaman, A. R. J. (1984). Electronic books and legibility: A microcomputer simulation. (Doctoral dissertation, University of Washington, 1984). Dissertation Abstracts International, 45, 1273A.

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